# ULTRASONIC WELDING PROCESS AND EQUIPMENT FOR CONSTRUCTION OF ELECTRON-TUBE MOUNTS

Tenth Quarterly Progress Report
For the Period
October 1 through December 31, 1964

Contract No. DA-36-039-sc86741
Order No. 19063-PP-62-81-81



Placed by
Industrial Engineering Division
United States Army Electronics Command
225 South Eighteenth Street
Philadelphia, Pennsylvania



AEROPROJECTS INCORPORATED
West Chester, Pennsylvania

# ULTRASONIC WELDING PROCESS AND EQUIPMENT FOR CONSTRUCTION OF ELECTRON-TUBE MOUNTS

Tenth Quarterly Progress Report
For the Period
October 1 through December 31, 1964

The object of this program is to design and construct prototype welding equipments and their associated accessories to perform by ultrasonic techniques the welding operations required in the assembly of electron tubes.

Contract No. DA-36-039-sc86741
Order No. 19063-PP-62-81-81

Specifications SCS-114A, SCIPPR-15
and MIL-E-1/1121A

Report Prepared by: J. G. Thomas

Report Approved by: J. Byron Jones

## ABSTRACT

During the period of operator training and preproduction evaluation with the 600-watt ultrasonic welder at Tung-Sol Electric Incorporated, difficulties developed with some of the special tools required for fabrication of the Type 6080WB electron tube. Some trouble was also experienced with replacements fabricated at Aeroprojects to the specifications of the original tools. Remedial action for these difficulties has been initiated, and tools have been redesigned for resistance to accidental damage. The 600-watt welder has been returned to Aeroprojects' laboratories for systematic check-out of the redesigned tooling and review of the assembly sequence for the Type 6080WB electron tube. Three welding tips and one anvil assembly have been fabricated and evaluated, and the remaining tooling revisions will be completed shortly.

Investigations with the tungsten-rhenium wire, as well as the molybdenum frame grid welding study, have been curtailed because of the effort required with the redesign and evaluation of the tube welding tools. A 600-watt welding tip for the frame grid welding study has been fabricated, and welding investigations will be resumed during the forthcoming report interval.

# TABLE OF CONTENTS

## LIST OF FIGURES

## PURPOSES

The objectives of this Production Engineering Measure (PEM) are to:

1. Demonstrate the capability limits of ultrasonic welding to join combinations of metallic materials of interest to the electron-tube industry. Devote major effort to making satisfactory joints in materials and geometries which might be difficult or impossible to join by other means.

2. Analyze the welding requirements for a specific electron tube - Type 6080WB. This type was selected by the U. S. Army Electronics Command because it has a record of failures due to metallic splatter caused by conventional welding techniques and improperly welded joints.

3. Redesign components of the Type 6080WB electron tube where possible, to permit ultrasonic welding of joints previously found impractical. This effort will result in a tube mount with as many connections as possible produced by ultrasonic welding so that evaluation of electron-tube performance will not be confused by the influence of metal-to-metal joints produced by other welding or joining techniques.

4. Determine the feasibility of joining 0.003-inch gold-plated molybdenum grid wires to 0.060-inch molybdenum side bars by ultrasonic welding for frame grid manufacture. If successful, redesign applicable components of the Type 6080WB electron-tube mount to permit the use of frame grids.

5. Prepare fixturing and tooling for the Type 6080WB electron tube, compatible with ultrasonic welding equipment.

6. Ultrasonically weld the parts required to assemble electron-tube mounts for the 6080WB tube type, and compare results obtained against similar sub-assemblies made by conventional joining methods. Tests will include strength and environmental tests.

7. Build production ultrasonic welding equipment which will enable an electron-tube manufacturer to make the welded connections in a broad range of electron-tube types.

8. Install the ultrasonic welding equipment in a production company, and produce on a pilot basis with that company's personnel a limited lot size of Type 6080WB electron tubes for subsequent evaluation in accordance with the applicable military specification.

# NARRATIVE AND DATA

## I. ELECTRON TUBE STUDY

### A. Tung-Sol Activity

Activity at Tung-Sol Electric Corporation facilities during this period has been concentrated upon training personnel in the operation of the 600-watt ultrasonic welder and in the assembly sequence required for the fabrication of the Type 6080WB electron-tube mounts with the special tooling provided with the welder. Operator training was preceded by equipment check-out by Aeroprojects field engineers at Tung-Sol and instruction of supervisory personnel. During a preproduction welding program conducted to familiarize personnel with operational and assembly procedures, difficulties with some of the welding tools and fixtures developed. Although the tools had been utilized effectively prior to delivery to Tung-Sol, sufficient repetitive welding had not been carried out to permit observation of the damage which later occurred.

The projection of the A-1 anvil tip (Sixth Quarterly Progress Report, page 4) fractured after extended welding; it was therefore redesigned and a replacement was fabricated by us. The anvil was replaced in service at Tung-Sol and satisfactory performance has been reported. Several hundred welds have since been made without damage. The redesign provides for replaceable inserts which can be attached simply to the tool body and discarded if damaged. During welding the tool body provides the insert with firm support, thus eliminating the bending movement of the projection which caused the fracture. Figure 1 shows the new anvil.

Difficulty was also experienced with welding tips T-2 and T-3 (Sixth Quarterly Progress Report). Tip T-2 fractured through the threads in the shank, and tip T-3 chipped at the front edge of the welding surface. Replacement tips, made from the same material as the original parts (Carpenter RDS tool steel), were fabricated by us and returned to Tung-Sol. A similar fracture occurred in the T-2 replacement after several hundred welds. The T-3 tip replacement chipped in a manner similar to the original, but continued to produce satisfactory welds after a flat surface was ground on the chipped face.

### B. Aeroprojects Activity

These instances of tool difficulties indicated that tooling improvements were required for repetitive production welding. Accordingly, the 600-watt welding machine and existing tooling in service at Tung-Sol were returned to Aeroprojects to permit a comprehensive review of tooling design and performance, particularly with regard to the requirements of the 6080WB

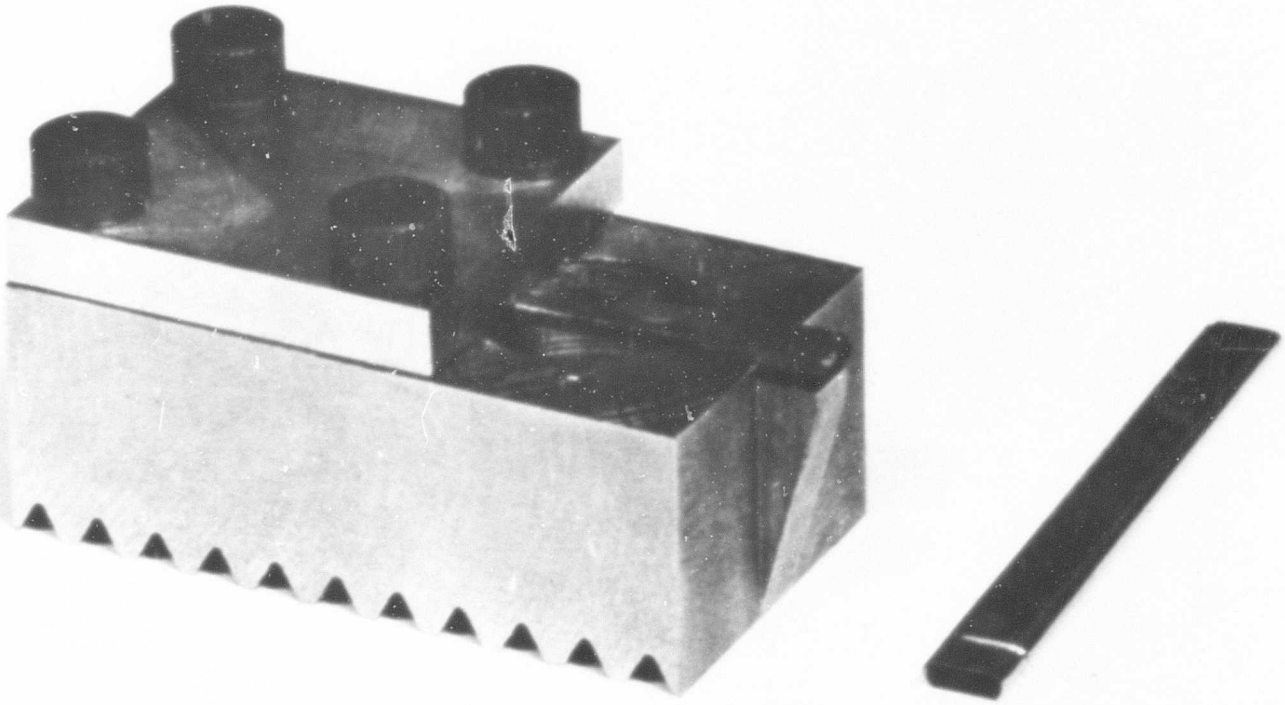


Figure 1

REDESIGNED A-1 ANVIL TIP SHOWING REPLACEABLE INSERT
(Scale: Approximately 3:1)

tube assembly. Verbal approval for return of the welder to Aeroprojects was obtained from the Project Officer on December 1, 1964, and, after arrangements with Tung-Sol were initiated, the welder was returned by Aeroprojects personnel on December 2, 1964. During the last three weeks in December, welder tooling was reviewed for isolation of causes of difficulties, and corrective redesign was begun.

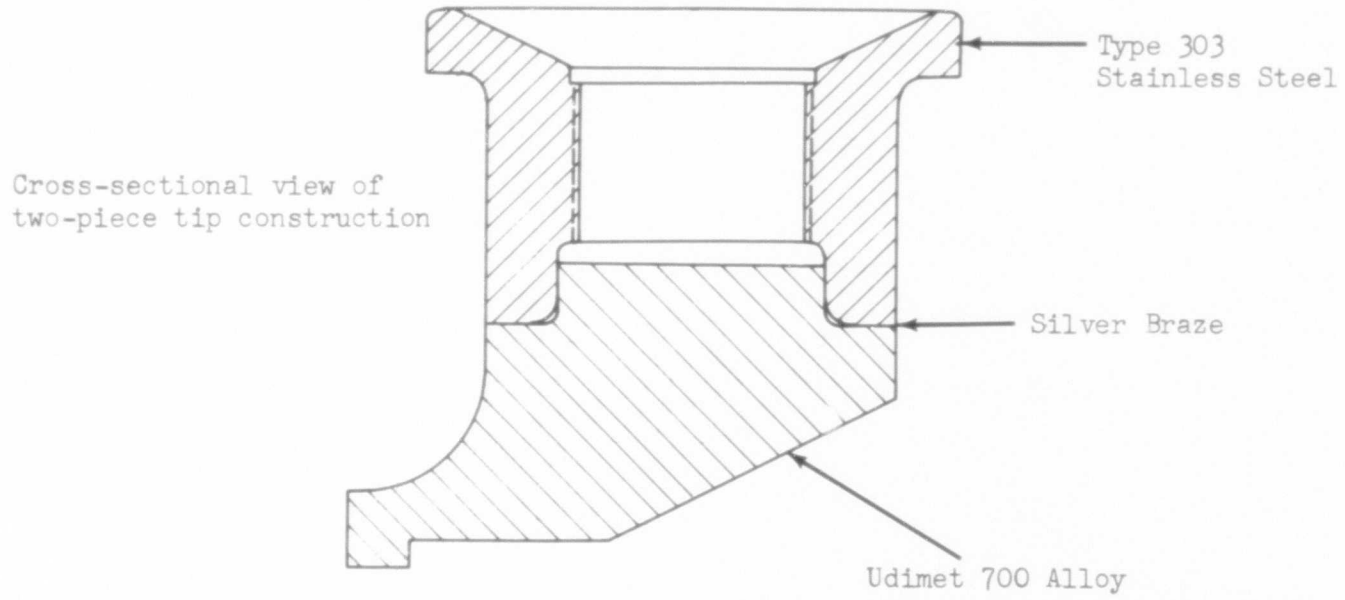
Causes of the difficulties have been reasonably well established; it appears that a sharp edge of the chamfer (i.e., the intersection of the chamfer and the outside diameter of the tool body) probably initiated the trouble.

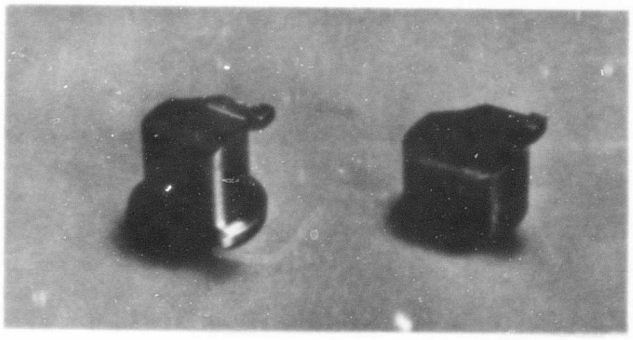
After thorough review of the tool designs, the first five tips in the Type 6080WB tube assembly sequence (T-1 through T-5) were redesigned. Redesign provided for a two-piece construction (comprising a type 303 stainless steel body to which a working face of Udimet 700 alloy is attached with silver braze) which eliminates costly machining operations on the difficult-to-machine Udimet 700 alloy. (See Figure 2 which is a representation of this two-piece cross section.) The stainless steel body has a reinforcing ring in the chamfer area where the earlier difficulties apparently originated. The superior service life demonstrated in earlier work by Udimet 700 led to its selection as the tip face material.

Redesigned tips T-1, T-2 and T-3 were then fabricated. Acoustic checkout was followed by welding use studies, which continue in progress. Photographs of the original tool steel tips and the revised tips are shown in Figure 2.

In addition, anvil A-2 (Sixth Quarterly Progress Report, p. 5) was redesigned and fabricated with the replaceable insert feature which had proved satisfactory in the redesigned anvil tip A-1. The new A-2 anvil has been acoustically checked and found satisfactory, and welding performance is being evaluated. Figure 3 shows the new anvil. The small drill-rod insert provides a positive stop for locating the anode support rod during welding of the eyelets to the support rods.

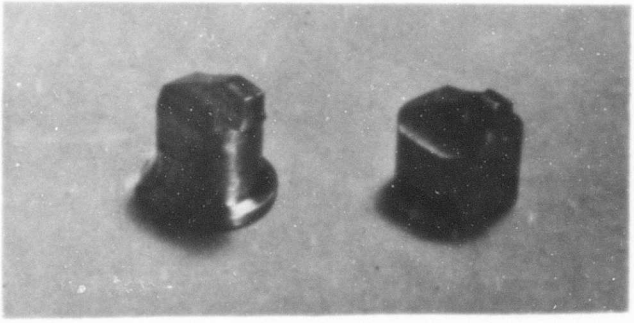
During December, the assembly sequence devised for the fabrication of the Type 6080WB tube was also reexamined. The objective of the reexamination was the assessment of the sequence in relation to the tooling redesign to effect improved assembly operations. This analysis is still in progress.



New Design Old Design

1



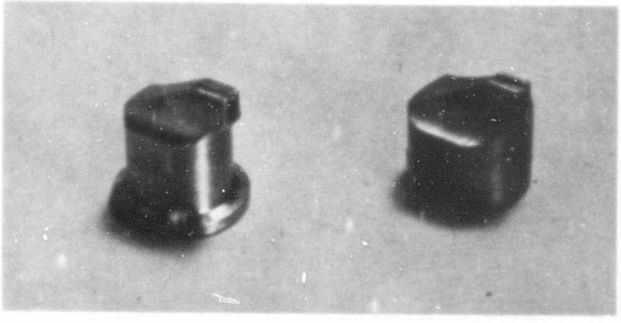
New Design Old Design

B

Tip

C

Tip T-3



New Design Old Design

Figure 2

MODIFIED WELDING TIPS
NEW TWO-PIECE CONSTRUCTION TIPS (Left)
ORIGINAL TIPS ARE SHOWN AT RIGHT
(Scale of photographs: 1:1)

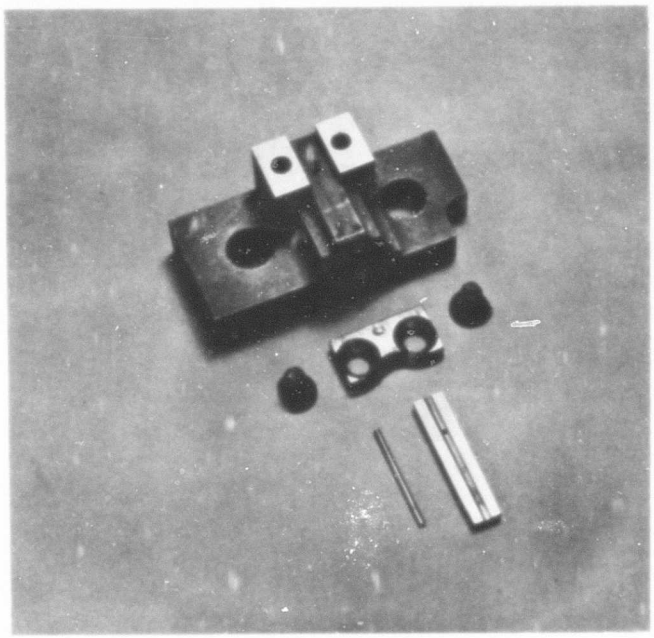


Figure 3

REDESIGNED ANVIL TIP A-2
(Scale: Approximately 1:1)

## II. COMPONENTS WELDING

### A. Tungsten-Rhenium Wire Welding

The grooved welding tip described in Quarterly Progress Report No. 9 did not alleviate the cracking of the 0.003-inch W-3 Re wire during welding to 0.060-inch tungsten sheet. After several welding attempts, the small groove (0.003-inch diameter by 0.0015-inch deep) had been damaged by the fractured wire fragments and required redressing. Effort to resolve this problem has been postponed until a welding tip, designed for the frame-grid welding study described below, can be fabricated and evaluated.

### B. Frame-Grid Welding

Analysis of the frame-grid welding operation has been completed, and initial welding studies of the frame-grid components (0.003-inch diameter gold-plated molybdenum wire and 0.060-inch molybdenum rod) have been carried out with a 300-watt welder. Both grooved and spherically contoured tips were used to determine welding response, and incipient bonding was achieved at the maximum power capability of the welder. Only single wire-to-rod welds were attempted during this preliminary work.

Bonding was achieved with the 600-watt welder in the tungsten-rhenium wire welding study, and it appears that similar power capability will be required for the frame-grid components. Accordingly, a 600-watt welder tip has been designed to bond two grid wires simultaneously to the frame rod. Work will be resumed as soon as the welding tip is fabricated.

Frame grids have not yet been received from Tung-Sol, but immediate delivery has been promised. Sufficient material is available, however, to proceed with preliminary welding investigations.

## III. CONCLUSIONS

A review of tooling and assembly sequence of the Type 6080WB electron tube was initiated at Aeroprojects after difficulties were experienced by Tung-Sol personnel with existing equipment and procedures. Improved tooling has been designed, fabricated, and utilized with success.

Progress on the tungsten-rhenium wire welding and frame-grid welding phases of this work has been delayed by the effort required for tooling redesign and test in connection with the tube welding effort at Tung-Sol. Study of both problems will proceed shortly.

## PROGRAM FOR NEXT INTERVAL

The fabrication of improved tooling (T-4 and T-5) and assembly sequence of Type 6080WB electron tube mounts will be completed, and delivery of the redesigned tooling and welder will be made to Tung-Sol as soon as possible (anticipated date is mid-February, 1965). Tooling and assembly sequence improvements will be fully evaluated at Aeroprojects, and tube mounts will be fabricated prior to return of the welding equipment to Tung-Sol. With engineering assistance supplied by Aeroprojects as required, Tung-Sol should be able to initiate final tube assemblies for test by early March, 1965.

Specially designed welding tools for the tungsten-rhenium wire and frame-grid work will be available shortly. Effort on these operations will be resumed during the next reporting period.

## PUBLICATIONS AND REPORTS

No publications or reports have been issued during this reporting period.

Technical consultation regarding the tube welding program was held with Messrs. B. Steiger and H. Helmstetter at Tung-Sol, Bloomfield, New Jersey, on November 26, 1964. Messrs. J. G. Thomas and T. A. Walraven of Aeroprojects attended.

The 600-watt welder at Tung-Sol was picked up by Mr. Walraven and an assisting Aeroprojects technician on December 2, 1964, and returned to Aeroprojects on the same date.

Technical consultation between Mr. Harry Shienbloom and Mr. J. G. Thomas was held at USAECOM headquarters, Philadelphia, Pennsylvania, on November 3, 1964. This meeting was held to discuss technical progress and review the program status.

## TECHNICAL MAN-HOURS

## EXPENDED DURING THIS REPORT PERIOD

| Aeroprojects | Project | Hours Expended During This Report Period |
|---|---|---|
| J. G. Thomas | Project Engineer | 89-1/2 |
| T. A. Walraven | Senior Welding Technician | 45 |
| H. L. McKaig | Vice President | 0 |
| A. L. Fuchs | Chief Design Engineer | 14 |
| Engineering | | 142 |
| Shop | | 66 |
| | Sub Total | 356-1/2 |
| **Tung-Sol Electric Incorporated** | | |
| B. F. Steiger | | 0 |
| N. Helmstetter | | 40 |
| | Sub Total | 40 |
| | TOTAL | 396-1/2 |

PROJE

| | Year | 1962 | | | | | | 1963 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quarter | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | |
| | Month | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 6 |
| PHASE I | | | | | | | | | | | | | | | | |
| BASIC WELD STUDY | | | | | | | | | | | | | | | | |
| TUBE STUDY | | | | | | | | | | | | | | | | |
| WELDING EQUIPMENT (Construction) | 100 w | | | | | | | | | | | | | | | |
| | 600 w | | | | | | | | | | | | | | | |
| | 4-kw | | | | | | | | | | | | | | | |
| EQUIPMENT AND TOOLING CHECKOUT | | | | | | | | | | | | | | | | |
| W-Re WIRE WELDING STUDY | | | | | | | | | | | | | | | | |
| FRAME GRID WELDING STUDY | | | | | | | | | | | | | | | | |
| 6080WB REDESIGN | | | | | | | | | | | | | | | | |
| PHASE II | | | | | | | | | | | | | | | | |
| WELDING EQUIPMENT (Delivery) | 100 w | | | | | | | | | | | | | | | |
| | 600 w | | | | | | | | | | | | | | | |
| | 4-kw | | | | | | | | | | | | | | | |
| INSTRUCTION MANUALS | | | | | | | | | | | | | | | | |
| REPRODUCIBLE DRAWINGS | | | | | | | | | | | | | | | | |
| SPECIAL SPARE PARTS | | | | | | | | | | | | | | | | |
| PHASE III | | | | | | | | | | | | | | | | |
| TUNG-SOL ACTIVITY | | | | | | | | | | | | | | | | |
| Training | | | | | | | | | | | | | | | | |
| Tube Assembly | | | | | | | | | | | | | | | | |
| Age and Test | | | | | | | | | | | | | | | | |
| Life Test | | | | | | | | | | | | | | | | |
| Data Compilation | | | | | | | | | | | | | | | | |
| METALLURGICAL EXAMINATION REPORT | | | | | | | | | | | | | | | | |
| QUARTERLY PROGRESS REPORTS | | | ● | | | ● | | | ● | | | ● | | | ● | |
| FINAL SUMMARY REPORT | | | | | | | | | | | | | | | | |

COMPLETED

COMPLETED

COMPLETED

COMPLETED

COMPLETED

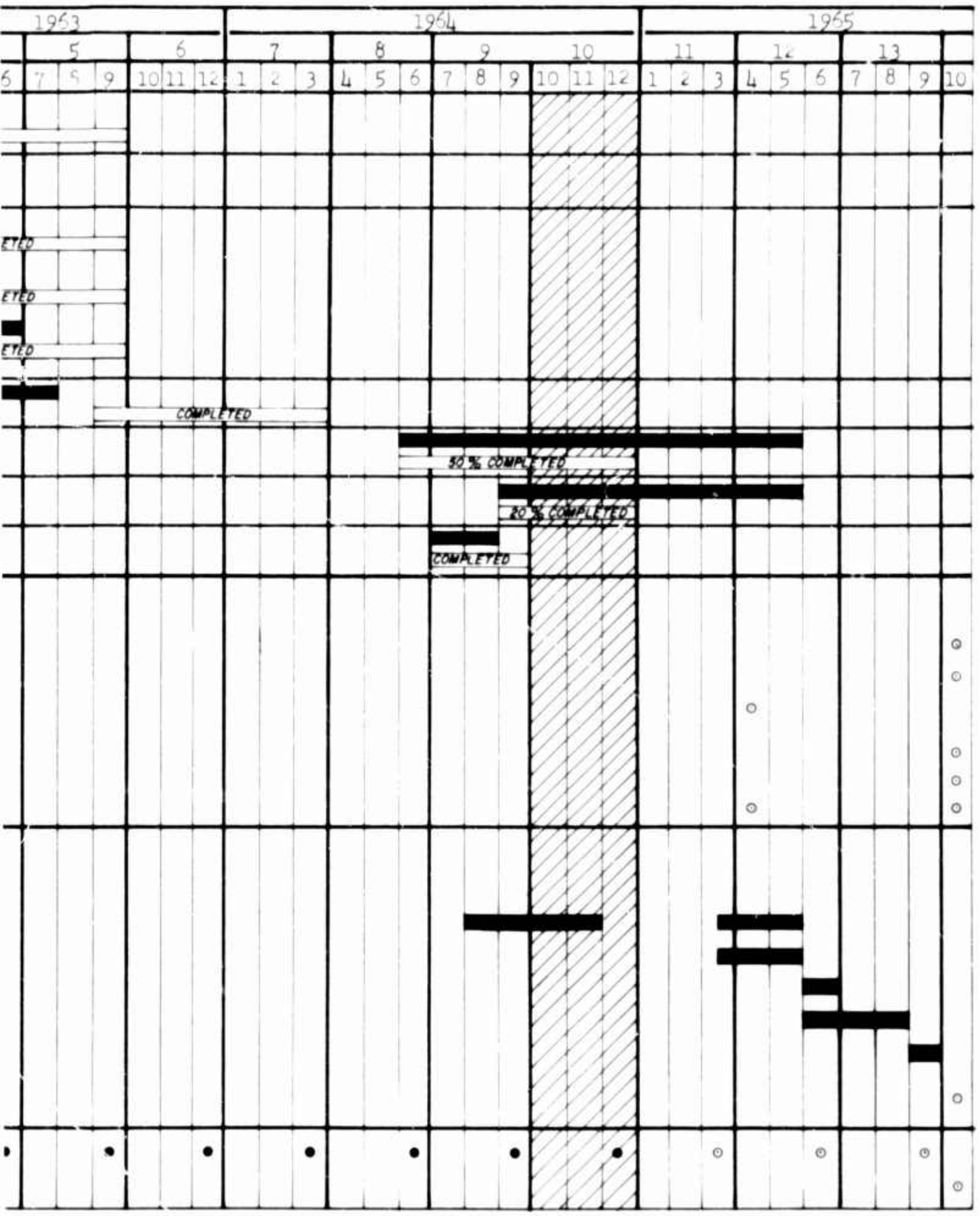
ET

ET

ET

LEGEND: ■ Proposed Work Schedule
▭ Work in Progress
○ Contractual Delivery Date
● Contractual Item Delivered
○ Amended Delivery Date
▨ Present Report Period

PROJECT SCHEDULE



Technical surveillance of this contract is under the control of the Industrial Engineering Division, USAECOM, Philadelphia, Pennsylvania 19103. For further technical information contact Mr. Harry Shienbloom, Project Engineer, Telephone No. Area Code 215-KI6-3200, Extension 2137.

# DISTRIBUTION LIST

| No. of Copies | |
|---|---|
| 2 | Advisory Group on Electron Devices<br>346 Broadway - 8th Floor<br>New York, New York 10013 |
| 1 | Commander<br>Aeronautical Systems Division<br>Wright-Patterson Air Force Base<br>Dayton, Ohio |
| 3 | Commanding General<br>U. S. Army Electronics Command<br>225 South 18th Street<br>Philadelphia 3, Pennsylvania<br>Attn: SELMA-R2b |
| 1 | Commanding General<br>U. S. Army Electronics Command<br>Fort Monmouth, New Jersey 07703<br>Attn: AMSEL-PP-E-CMD-1 |
| 1 | Director<br>U. S. Army Electronics Laboratories<br>Fort Monmouth, New Jersey<br>Attn: AMSEL-RD-PR, Chief, Tube Techniques Branch |
| 1 | Attn: Chief, General Tubes Branch |
| 1 | Attn: Chief, Gaseous Electronics Section, Bldg. S-53 |
| 10 | Commander<br>Defense Documentation Center<br>Cameron Station<br>Alexandria, Virginia, 22314<br>Attn: TISIA-1 |
| 1 | Canadian Liaison Officer<br>Army Materiel Command<br>Tempo 7, Room 1067<br>Washington, D. C. 20315 |
| 1 | Eitel-McCullough, Inc.<br>301 Industrial Way<br>San Carlos, California<br>Attn: Mr. H. M. Bailey |
| 1 | Chief, Bureau of Ships<br>Department of the Navy<br>Washington 25, D. C.<br>Attn: 691A |
| 1 | Amperex Electronic Corporation<br>230 Duffy Avenue<br>Hicksville, L. I., New York<br>Attn: Mr. Alex Mitchell |
| 1 | Bell Telephone Laboratories<br>Technical Reports Center<br>Whippany, New Jersey<br>Attn: Miss Nan Farley |
| 1 | The Bendix Corporation<br>Red Bank Division<br>Eatontown, New Jersey<br>Attn: Mr. Joseph F. Bozzelli |
| 1 | Bomac Laboratories, Inc.<br>Salem Road<br>Beverly, Massachusetts<br>Attn: Mr. Richard S. Briggs |
| 1 | Burroughs Corporation<br>Electronic Tube Division<br>P. O. Box 1226<br>Plainfield, New Jersey<br>Attn: Mr. Roger Wolfe |
| 1 | Allen B. DuMont Laboratories, Inc.<br>750 Bloomfield Avenue<br>Clifton, New Jersey<br>Attn: Mr. Robert Deutsch |
| 1 | Edgerton, Germeshausen & Grier, Inc.<br>Crosby Drive<br>Bedford 15, Massachusetts 01730<br>Attn: Mr. S. Goldberg |

DISTRIBUTION LIST (Continued)

| No. of Copies | |
|---|---|
| 1 | Electronic Enterprises, Inc.<br>65-67 Seventh Avenue<br>Newark 4, New Jersey<br>Attn: Mr. Richard Bloemeke |
| 1 | Electrons, Inc.<br>127 Sussex Avenue<br>Newark 3, New Jersey<br>Attn: Mr. E. K. Smith |
| 1 | General Electric Company<br>316 East Ninth Street<br>Owensboro, Kentucky<br>Attn: Mr. W. T. Millis |
| 1 | Gulton Industries, Inc.<br>212 Durham Avenue<br>Metuchen, New Jersey<br>Attn: Mr. Daniel Abrams |
| 1 | Huggins Laboratories<br>999 East Argues Avenue<br>Sunnyvale, California<br>Attn: Mr. R. A. Huggins |
| 1 | Hughes Aircraft<br>Vacuum Tube Products<br>2020 Short Street<br>Oceanside, California<br>Attn: Mr. James Sutherland |
| 1 | International Telephone & Telegraph Corporation<br>Electron Tube Division<br>P. O. Box 100<br>Easton, Pennsylvania<br>Attn: Mr. R. F. Mann |
| 1 | Lionel Electronic Laboratories, Inc.<br>1226 Flushing Avenue<br>Brooklyn 37, New York |
| 1 | Litton Engineering Laboratories<br>P. O. Box 949<br>Grass Valley, California<br>Attn: Mr. Charles V. Litton |
| 1 | Litton Industries<br>Electron Tube Division<br>San Carlos, California<br>Attn: Mr. James H. Weber |
| 1 | Machlett Laboratories, Inc.<br>1063 Hope Street<br>Springdale, Connecticut<br>Attn: Dr. H. D. Doolittle |
| 1 | Metcom, Inc.<br>76 Lafayette Street<br>Salem, Massachusetts<br>Attn: Mr. Richard Broderick |
| 1 | Microwave Associates, Inc.<br>South Street<br>Burlington, Massachusetts<br>Attn: Dr. L. Gould |
| 1 | Microwave Electronics Corporation<br>4061 Transport Street<br>Palo Alto, California<br>Attn: Dr. Stanley Kaisel |
| 1 | Ohio State University<br>Department of Metallurgy<br>Columbus, Ohio<br>Attn: Mr. Frederick J. Fraikor |

DISTRIBUTION LIST (Continued)

| No. of Copies | |
|---|---|
| 1 | Penta Laboratories, Inc.<br>312 North Nopal Street<br>Santa Barbara, California<br>Attn: Mr. R. L. Norton |
| 1 | Philco Corporation<br>Lansdale Division<br>Church Road<br>Attn: Mr. F. Mayock |
| 1 | Polarad Electronics Corporation<br>43-20 Thirty-fourth Street<br>Long Island City 1, New York<br>Attn: Dr. D. L. Jaffe |
| 1 | Radio Corporation of America<br>Electron Tube Division<br>Lancaster, Pennsylvania<br>Attn: Mr. Roy E. Nelson |
| 1 | Radio Corporation of America<br>Electron Tube Division<br>415 South Fifth Street<br>Harrison, New Jersey<br>Attn: Mr. Clarence West |
| 1 | Raytheon Company<br>Industrial Components Division<br>55 Chapel Street<br>Newton 58, Massachusetts<br>Attn: Mr. Paul R. Keeler |
| 1 | S. F. D. Laboratories, Inc.<br>800 Rahway Avenue<br>Union, New Jersey<br>Attn: Dr. Joseph Saloom |
| 1 | Sonotone Corporation<br>Box 200<br>Elmsford, New York<br>Attn: Dr. L. G. Hector |

| No. of Copies | |
|---|---|
| 1 | Sperry Electronic Tube Division<br>Sperry Rand<br>Gainesville, Florida<br>Attn: Mr. John Whitford |
| 1 | Sylvania Electric Products, Inc.<br>Emporium, Pennsylvania<br>Attn: Mr. Vincent Frubbe |
| 1 | Tucor, Inc.<br>59 Danbury Road<br>Wilton, Connecticut<br>Attn: Mr. R. White |
| 1 | Tung-Sol Electric, Inc.<br>200 Bloomfield Avenue<br>Bloomfield, New Jersey<br>Attn: Mr. Max Yarmovsky |
| 1 | United Electronics Company<br>42 Spring Street<br>Newark, New Jersey<br>Attn: Dr. John Beers |
| 1 | Varian Associates<br>611 Hansen Way<br>Palo Alto, California<br>Attn: Dr. Richard Nelson |
| 1 | The Victoreen Instrument Company<br>5806 Hough Avenue<br>Cleveland 3, Ohio<br>Attn: Mr. Ben Olson |
| 1 | Watkins-Johnson Company<br>3333 Hillview Avenue<br>Palo Alto, California<br>Attn: Dr. Rolf Peter |
| 1 | Westinghouse Electric Corporation<br>Electronic Tube Division<br>Box 284<br>Elmira, New York<br>Attn: Mr. B. W. Sauter |

DISTRIBUTION LIST (Continued)

| No. of Copies | |
|---|---|
| 1 | U. S. Army Ordnance<br>Frankford Arsenal<br>Bridge & Tacony Streets<br>Philadelphia, Pennsylvania 19137<br>Attn: Mr. Frank Hussey<br>Metal Joining Section<br>1323, 64-1 |
| 1 | Battelle Memorial Institute<br>505 King Avenue<br>Columbus 1, Ohio<br>Attn: Mr. C. M. Jackson |
| 1 | Westinghouse Electric Corporation<br>Youngwood, Pennsylvania<br>Attention: Mr. Ozzie Jaeger |
| 1 | Clevite Transistor<br>A Division of Clevite Corporation<br>200 Smith Street<br>Waltham 54, Massachusetts<br>Attention: Mr. Sam Rubinovitz |
| 1 | Rome Air Development Center<br>Griffiss Air Force Base, New York<br>Attention: Mr. L. Gubbins, RASGR |
| 1 | Hamilton Standard Division<br>United Aircraft Corporation<br>Windsor Locks, Connecticut<br>Attn: Mr. John Dudenhoefer<br>Project Director |
| 1 | Mr. C. W. Irish<br>Marketing Section<br>Lamp Metals & Components Dept.<br>General Electric Company<br>21800 Tungsten Road<br>Cleveland 17, Ohio |
| 1 | Radio Corporation of America<br>Somerville, New Jersey<br>Attention: Mr. R. Wicks |

| No. of Copies | |
|---|---|
| 1 | Raytheon Manufacturing Company<br>Chelmsford Street<br>Lowell, Massachusetts<br>Attention: Mr. W. W. Robinson |
| 1 | Sprague Electric Company<br>87 Marshall Street<br>North Adams, Massachusetts<br>Attention: Mr. W. Bell |
| 1 | Texas Instruments, Inc.<br>Semiconductor Components Division<br>Post Office Box 5012<br>Dallas 22, Texas<br>Attention: Semiconductor Library |
| 1 | Transitron Electronic Corporation<br>168-182 Albion Street<br>Wakefield, Massachusetts<br>Attention: Dr. D. Bakalar |
| 2 | Western Electric Company<br>Marion and Vine Streets<br>Laureldale, Pennsylvania<br>Attention: Mr. Robert Moore |
| 1 | Delco Radio Division<br>Kokomo, Indiana<br>Attention: Dr. F. E. Jaumot, Jr. |
| 1 | Bendix Corporation<br>Semiconductor Division<br>Holmdel, New Jersey<br>Attention: Dr. Robert Meijer |
| 1 | Motorola, Inc.<br>5005 East McDowell Road<br>Phoenix, Arizona<br>Attention: Mr. James LaRue |
| 1 | Pacific Semiconductors, Inc.<br>14520 S. Avaiation Blvd.<br>Lawndale, California<br>Attention: Dr. H. Q. North |

DISTRIBUTION LIST (Continued)

| No. of Copies | |
|---|---|
| 1 | General Electric Company<br>Electronic Park<br>Syracuse, New York<br>Attention: Mr. T. F. Kendall<br>Bldg. 7, Room 152 |
| 1 | Bureau of Weapons<br>Department of the Navy<br>Washington 25, D. C.<br>Attention: Mr. Roy G. Gustafson<br>RRMA-24, Materials Div. |
| 1 | The Rembar Company, Inc.<br>67 Main Street<br>Dobbs Ferry, New York<br>Attention: Mr. E. Dietz |
| 1 | Fairchild Semiconductor Corp.<br>545 Whisman Road<br>Mountain View, California<br>Attention: Mr. Ralph Lee |
| 1 | Radio Corporation of America<br>Electronic Components and Devices<br>Lancaster, Pennsylvania<br>Attn: Mr. Edward L. Romero |
| 1 | General Electric Company<br>Schenectady, New York<br>Attn: Dr. Harold R. Day<br>Building 5, Room 323 |
| 1 | Arinc Research Company<br>1700 "K" Street - NW<br>Washington, D. C. - 20006<br>Attn: Mr. Robert Reed |

| No. of Copies | |
|---|---|
| 1 | Sylvania Electric Products, Inc.<br>Div. of General Telephone Corp.<br>Sylvania Lighting Products Div.<br>60 Boston Street<br>Salem, Massachusetts<br>Attn: Mr. Rufus L. Briggs,<br>Project Eng.-SC |
| 1 | ITT Industrial Laboratories<br>3700 East Pontiac<br>Fort Wayne, Indiana<br>Attn: M. F. Toohig<br>Manager, Tubes and Sensors |
| 1 | Thermo Electron Engr. Corp.<br>85 First Avenue<br>Waltham, Massachusetts<br>Attn: Mr. T. Johnson |
| 1 | Raytheon Company<br>Second Avenue<br>Waltham, Massachusetts<br>Attn: Dr. Colin Bowness |
| 1 | Raytheon Company<br>Route 128<br>Burlington, Massachusetts<br>Attn: Mr. George Freedman |
| 1 | Ferrotec Company<br>217 California St.<br>Newton, Massachusetts<br>Attn: Mr. Paul Rutledge |
| 1 | IIT Research Institute<br>10 W. 35th Street<br>Chicago 16, Illinois<br>Attn: Mr. S. L. Blum |

DISTRIBUTION LIST (Concluded)

No. of Copies

1 Electron Technology, Incorporated
626 Schuyler Avenue
Kearny, New Jersey
Attention: Mr. Stanley Koch

1 Eon Corporation
175 Pearl Street
Brooklyn, New York
Attention: Dr. Gustav Weinberg

1 National Aeronautics & Space Administration
Head, Operation Section
Scientific & Technical Information Division
(SAK/DL)
4833 Rugby Avenue
Bethesda, Maryland 20014

1 National Aeronautics & Space Administration
Lewis Research Center
21000 Brook Park Road
Cleveland, Ohio 44135
Attention: Mr. Davies
Mail Code: 500-309

1 Commanding Officer
Harry Diamond Laboratories
Washington 25, D. C.
Attention: Mr. H. G. Chandler

1 General Electric Co.
Pickup Tube Operation
Room 165, Bldg. 6
Electronics Park
Syracuse, N. Y.
Attn: Mr. Philip Oakes

BLANK PAGE